

Six new lichen species (Ascomycota) from Australia

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Abstract

Six lichens (Ascomycota) are described as new from Australia: *Bapalmuia rotatilis* P.M.McCarthy & Elix (Pilocarpaceae; southern New South Wales), *Fellhanera incolorata* P.M.McCarthy & Elix (Pilocarpaceae; southern New South Wales), *Opegrapha gilmorei* P.M.McCarthy & Elix (Opegraphaceae; Bass Strait, Tasmania), *Protoparmelia ewersii* Elix & P.M.McCarthy (Parmeliaceae; Northern Territory, South Australia), *Ramboldia buleensis* Elix & P.M.McCarthy (Lecanoraceae; southern New South Wales) and *R. subplicatula* Elix & P.M.McCarthy (central-western New South Wales).

Introduction

Field studies and laboratory investigations continue to expand our understanding of Australian lichen diversity. In early 2017 the number of species and infra-specific taxa known from the six states and two mainland territories stood at 3677, including 1308 endemic taxa. Most recently, during the period January 2016 to February 2017, 79 lichens were added to the Australian flora, 60 of them newly described (McCarthy 2017).

In this contribution, six new lichen species are documented from Australia representing the genera *Bapalmuia* Sérus. (Pilocarpaceae), *Fellhanera* Vězda (Pilocarpaceae), *Opegrapha* Ach. (Opegraphaceae), *Protoparmelia* M.Choisy (Parmeliaceae) and *Ramboldia* Kantvilas & Elix (Lecanoraceae).

Methods

Observations and measurements of photobiont cells, thalline and apothecial anatomy, asci, ascospores, pycnidial anatomy and conidia were made on hand-cut sections mounted in water and treated with 10% potassium hydroxide (K), 50% nitric acid (N) and 10% hydrochloric acid (H). Calcium oxalate was detected by treatment of apothecial margins and medullary tissue with a 10% aqueous solution of sulfuric acid. It forms colourless, needle-shaped crystals that are readily observed under the stereomicroscope. Asci were also observed in Lugol's Iodine (I), with and without pre-treatment in K. Chemical constituents were identified by thin-layer chromatography (Elix 2014) and comparison with authentic samples.

New Species

1. *Bapalmuia rotatilis* P.M.McCarthy & Elix, **sp. nov.**

Distinguished from *B. halleana* Sérus. by the much larger apothecia, (0.5–)1.6(–3.1) mm diam. (0.5–0.8 mm in the latter), dark brown to blackish apothecial margins (not whitish to pale brown), ascospores with fewer transverse septa (7–17 rather than 20–30) and by the absence of lichen substances in the thallus (4,5-dichlorolichexanthone in *B. halleana*).

MycoBank No.: MB 820666

Type: Australia. New South Wales, South Coast (Jacobs and Pickard 1981), Buckenbowra River estuary, off Runnyford Road, 7.5 km W of Batemans Bay, 35°44'19"S, 150°08'07"E, at sea level, on dead *Avicennia marina* in mangrove swamp along tidal creek, J.A. Elix 23358, 29 Nov 1989 (holo: CANB).

Thallus crustose, epiphloeodal, forming colonies several centimetres wide, pale greyish yellow, yellowish green or pale green, 70–150 µm thick and effuse to continuous, dull to slightly glossy, smooth to irregularly verruculose and sparingly to richly rimose, or becoming considerably thicker [0.1–0.3(–0.5) mm] as verrucules develop into sparse to dense, globose granules 80–150 (–200) µm wide, these often segregating into plane areoles 1–3(–4) mm wide, or strings of granules forming simple or coralloid isidia up to 0.4(–0.5) mm long which are almost prostrate to erect, terete to slightly flattened and then appearing subsquamulose, esorediate. *Cortex* present on all surfaces, hyaline, 12–20(–30) µm thick, internally paraplectenchymatous, of thick-walled cells 2–4(–5) µm wide which become almost amorphous in a distal necral zone. *Algal layer* continuous, usually discrete and 30–60 µm thick; cells green, globose, 5–10(–12) µm wide. *Medulla* poorly delimited to well-defined and 30–70 µm thick, not impregnated with calcium oxalate (H₂SO₄–); hyphae loosely arranged, 2–3.5 µm wide. *Prothallus* thin, effuse and white, or blackish (when contiguous with thalli of other crustose species), but usually not apparent. *Apothecia* sparse to very numerous, subsessile to sessile and markedly constricted at the base (some appear adnate when they are overtopped by isidia), lecideine to biatorine, usually solitary and rounded, but often becoming irregular in shape, convoluted and contorted with age, occasionally clustered, then often distorted by mutual pressure, (0.5–)1.6(–3.1) mm diam. [*n* = 170], medium brown to brown-black or greyish black, frequently with a bluish hue and appearing faintly pruinose, usually uniform in colour, occasionally piebald; margin persistent and 80–150(–200) µm thick or becoming excluded, entire, flexuose or contorted or scalloped about the largest apothecia, usually concolorous with the disc above (occasionally medium to dark brown), very pale to medium brown below, the margins of immature and submature apothecia thick, prominent, commonly with deep radial grooves and with a sparse, white, cotton-like covering; disc initially concave to plane, smooth, matt, either remaining plane or becoming moderately to strongly convex or undulate. *Thalline excipulum* absent. *Proper excipulum* well-developed, cupulate, 60–150(–200) µm thick laterally (thin section), 150–250(–400) µm thick at the base (thinnest laterally and thickest basally in the most convex apothecia), of thick-walled, labyrinthine cells (with variously orientated 7–17 × 3–7 µm lumina) laterally which project as 20–50 µm long and 5–7 µm wide, hyaline, cellular hyphae that are most dense on the upper rim of prominent apothecial margins, shorter and more sparse lower down on the lateral excipulum and when the apothecial margin is excluded; excipulum adjacent to the hypothecium labyrinthine (lumina 3–7 × 1–3 µm), the latter subtended by labyrinthine cells tending towards prosoplectenchymatous at the very base (lumina 5–10 × 2–4 µm); occasionally the excipulum base impregnated with few or numerous discrete concentrations of calcium oxalate (H₂SO₄+); the most deeply pigmented areas of the lateral excipulum adjacent to the hymenium, dark brown, N+ red-brown, K+ pale red-brown; excipulum diffusely pale brown laterally and N–, K–, hyaline or very pale yellowish at the base. *Epihymenium* (8–)12–16(–20) µm thick, lightly encrusted with crystals or not, medium brown, aeruginose-black or brown-black, occasionally the pigment diffusing 30–50 µm down into the hymenium, K+ pale red-brown, N+ purple-brown fading over several minutes to red-brown. *Hypothecium* pale yellow to pale yellow-brown, 30–70(–100) µm thick (thickest in the most convex apothecia), paraplectenchymatous to labyrinthine, the cells 2–4 µm wide, K–, I–, N+ very weak red-brown. *Hymenium* 90–140 µm thick, not interspersed with granules or oil globules, I+ blue, K–, N–; *paraphyses* conglutinate in water, not loosening in K, mostly unbranched, although sometimes sparingly branched below the apices, lacking anastomoses, 1–1.5 µm thick, long-celled below, but much shorter-celled near the apices; apical cells not or scarcely swollen (clavate and 1.5–2.5 µm wide), not pigmented. *Asci* narrowly clavate or cylindroclavate, 75–102 × 9–14 µm, (4–)8-spored, *Byssoloma*-type (Hafellner 1984); tholus amyloid, with a darker, vertical, tubular structure. *Ascospores* colourless, arranged in a single fascicle in the ascus, (7–)9–15(–17)-septate (the septa uniformly or irregularly spaced), narrowly cylindrical to filiform, usually straight, occasionally a little curved, rarely faintly sigmoidal outside the ascus, commonly tapering more gradually towards the proximal end, not constricted at the septa, (42–)69(–90) × (2.5–)3.5(–4.5) µm [*n* = 100; ratio of length to breadth 11–20(–30):1; small numbers of

aberrant ascospores in 4-spored asci of *J.A. Elix 45712* up to 6 µm wide c. one-third back from the distal apex], thin-walled, lacking a distinct perispore; distal apex rather rounded to acute, the proximal apex acute; contents clear. *Pycnidia* not seen. **Figs 1, 2.**

Chemistry: Thallus K–, C–, KC–, PD–, UV–; no substances detected by TLC.

Relationships: *Bapalmuia* Sérus. (Pilocarpaceae) is characterized by the combination of plane to mostly convex apothecia, a persistent or excluded proper excipulum with a prosoplectenchymatous or labyrinthine structure, simple paraphyses with or without slightly swollen apices, narrowly cylindrical to acicular, multiseptate ascospores and, critically, *Byssoloma*-type asci, i.e. with an amyloid tholus incorporating a darker blue, vertical, tubular structure. These characters distinguish this genus from *Bacidia* De Not. (Ramalinaceae), the original repository of many of the current species and their taxonomic synonyms (Sérusiaux 1993, Kalb et al. 2000, Kalb 2008, Lücking 2008). Most taxa, but not all, produce 4,5-dichlorolichexanthone. Nineteen species are currently known from the bark and/or leaves of forest trees mainly in the Neotropics and tropical Africa, but also in the Palaeotropics and at subtropical latitudes worldwide. Three are already known from Australia (McCarthy 2017), viz. the pantropical, foliicolous *B. palmularis* (Müll.Arg.) Sérus. and the endemic, foliicolous *B. sorediata* Kalb & Lücking, both from eastern Queensland, and *B. buchananii* (Stirt.) Kalb & Lücking, the most common and widespread species, which grows on bark and overgrows corticolous bryophytes in eastern and south-eastern Australia as well as New Zealand (Kalb et al. 2000).

Bapalmuia rotatilis is a robust and distinctive species that exhibits broad continua of thallus and ascomatal morphology, expressing both the diagnostic attributes of the genus (ultimately biatorine apothecia, excipular anatomy, simple paraphyses with scarcely swollen apices, *Byssoloma*-type asci and acicular ascospores) as well as a suite of characters that separate it from all other species of the genus (the verruculose, densely granulose or isidiate, corticolous thallus, large, dark, sessile apothecia with a distinctively labyrinthine and mostly pale excipulum with the outermost hyphae often projecting, ascospores 42–90 × 2.5–4.5 µm with (7–)9–15(–17) septa, and the absence of thalline xanthonenes). *Bapalmuia halleana* Sérus., a corticolous and foliicolous species from tropical Africa, has a rather similar thallus and excipular anatomy, but the apothecia are smaller (0.5–0.8 mm diam.) with a much paler excipulum, the similar-sized ascospores are 20–30-septate, and the thallus contains xanthonenes (Kalb et al. 2000). The corticolous and bryophilous *B. confusa* Kalb & Lücking, from Brazil, has a comparatively thin thallus containing 4,5-dichlorolichexanthone, apothecia of similar size and construction to the new Australian species, although much paler in colour, while the ascospores of the Brazilian lichen are 100–150 × 4.5–6 µm with 35–40 septa (Kalb et al. 2000). Finally, the sympatric *B. buchananii*, the only other temperate-austral species currently in the genus, has a granular-effuse to coralloid thallus containing 4,5-dichlorolichexanthone, apothecia of similar size to *B. rotatilis*, but which are basally constricted to substipitate and immarginate from early in their development, with a hypothecium to c. 350 µm thick and ascospores 130–240 × 3–3.5 µm with 25–75-septa (Kalb et al. 2000).

Etymology: The epithet *rotatilis* (L. wheel-like) refers the appearance of most immature apothecia which have a radially fissured margin (Fig. 1A).

Distribution and habitat: The type and most other collections were corticolous or lignicolous on *Avicennia marina* and *Allocasuarina glauca* in moist strand vegetation in and adjacent to a mangrove swamp on the south coast of New South Wales, Australia. Associated species included *Bacidia johnstoniae* Elix, *Caloplaca pulcherrima* (Müll.Arg.) S.Y.Kondr. & Kärnefelt, *Chrysothrix xanthina* (Vain.) Kalb, *Dirinaria appplanata* (Fée) D.D.Awasthi, *Lecanographa microcarpella* (Müll.Arg.) Egea & Torrente, *Megalaria orokonuiana* Fryday & A.Knight, *Pannaria elixii* P.M.Jørg. & D.J.Galloway, *Parmelina conlabrosa* (Hale) Elix & J.Johnst., *Parmotrema crinitum* (Ach.) M.Choisy, *P. reticulatum* (Taylor) M.Choisy, *P. tinctorum* (Nyl.) Hale and *Relicina sydneyensis* (Gyeln.) Hale. The second site, c. 20 km south-east of the type locality, is drier and more elevated, and the lichen grew on *Acacia* bark.

Additional specimens examined: NEW SOUTH WALES: South Coast: type locality, alt. 5 m, on *Allocasuarina glauca* in strand vegetation along a tidal creek, *J.A. Elix 21863* & *K. Kalb*, 4 Aug 1988 (CANB); *loc. id.*, alt. 1 m, on *Avicennia marina*, *J.A. Elix 23355, 23340, 23370*, 29 Nov 1989 (CANB, dup. of 23355 in B); *loc. id.*, on *Avicennia marina* in *Avicennia-Aegiceras*-dominated riverside, *J.A. Elix 26586, 26593*, 15 Mar 1992 (CANB, dup. B); *loc. id.*, alt. 1 m, on *Allocasuarina glauca*, *J.A. Elix 23332*, 29 Nov 1989 (CANB); *loc. id.*, alt. 3 m, on dead *Allocasuarina* along a tidal creek, *J.A. Elix 45712*, 17 Sep 2008 (CANB); Burri Heights, 1 km W of Tomakin, 35°51'S, 150°11'E, alt. 20 m, on *Acacia* in coastal forest dominated by *Eucalyptus maculata* and *Acacia*, *J.A. Elix 22016*, 21 Jan 1989 (CANB).

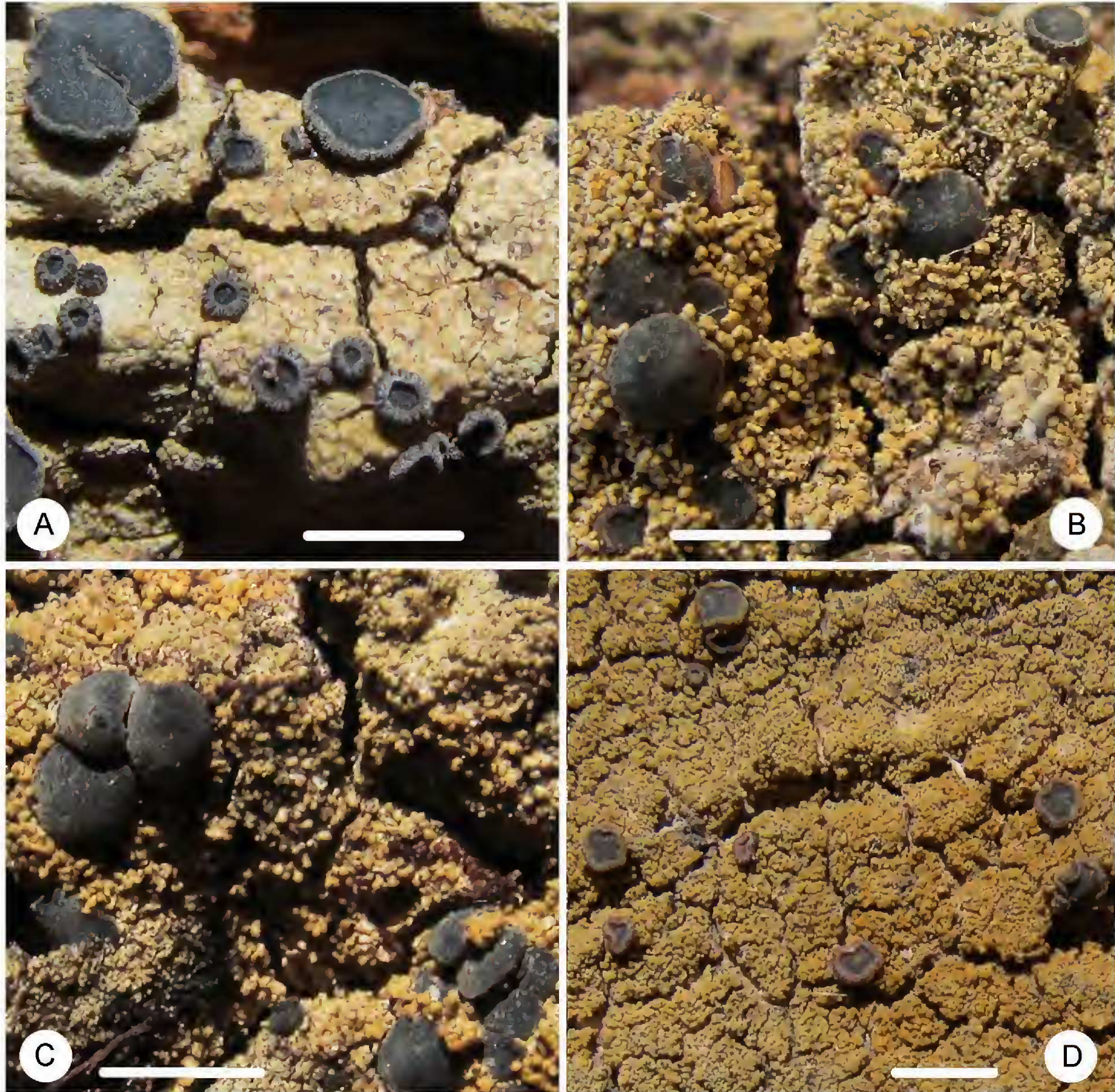


Fig 1. *Bapalmuia rotatilis*. Variation in thalline and apothecial morphology. A, holotype; B, J.A. Elix 45712; C, J.A. Elix 23332; D, J.A. Elix 23355. Scale bars = 2 mm.

2. *Fellhanera incolorata* P.M.McCarthy & Elix sp. nov.

Distinguished from *F. bouteillei* (Desm.) Vězda by the whitish, verruculose thallus (bluish grey or bluish green and granulose in the latter) containing atranorin and thuringione (as opposed to usnic and isousnic acids), apothecia 0.42–1 mm in diameter (0.1–0.4 mm in *F. bouteillei*) and broadly pyriform conidia $2.5\text{--}3.5 \times 2\text{--}2.5 \mu\text{m}$ (narrower and $3\text{--}5 \times 1.5\text{--}2 \mu\text{m}$ in *F. bouteillei*).

MycoBank No.: MB 820667

Type: Australia. New South Wales, South Coast, Mundarlow Creek estuary, off Runnyford Road, 7.5 km W of Batemans Bay, $35^{\circ}44'19''\text{S}$, $150^{\circ}08'07''\text{E}$, at sea level, on narrow branches and twigs of *Avicennia marina* in mangrove swamp along tidal creek, P.M. McCarthy 4526, 19 Nov 2016 (holo: CANB).

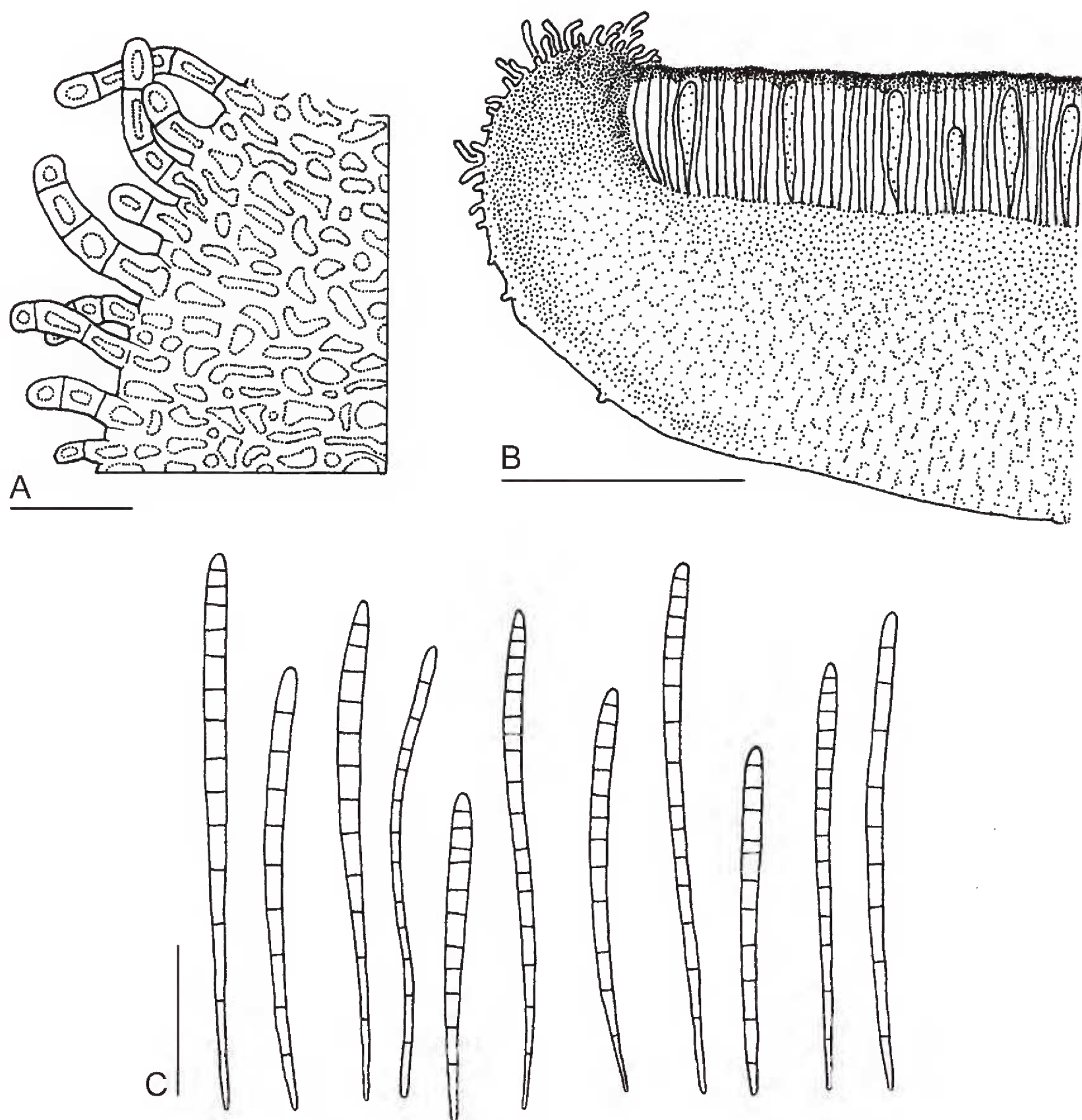


Fig 2. *Bapalmuia rotatilis*. **A**, part of a sectioned apothecium (semi-schematic; holotype); **B**, labyrinthine excipular tissue with projecting hyphae (J.A. Elix 23355); **C**, ascospores (J.A. Elix 23332). Scale bars: **A** = 0.2 mm; **B**, **C** = 20 μ m.

Thallus crustose, epiphloeodal, continuous and forming discrete, often orbicular colonies to 5 cm wide, to 80(–120) μ m thick, pale greyish white, creamy white or patchily very pale green, sparingly to richly but thinly rimose, dull to somewhat glossy, usually abundantly verruculose, the verrucules c. 0.1 mm wide, mostly rounded, low to moderately or strongly convex or hemispherical, occasionally almost tuberculate, the thallus often minutely and inconspicuously areolate around individual verrucules. *Cortex* absent, but the uppermost 10–15 μ m of the thallus often free of algae. *Algal layer* continuous, discrete and 30–70 μ m deep, or algae occupying most of the thallus; cells green, globose, 7–14 μ m diam. *Medulla* poorly delimited, not impregnated with calcium oxalate (H_2SO_4^-); hyphae 2.5–4 μ m wide, thin-walled. *Thallus margin* thin, effuse; prothallus not apparent. *Apothecia* numerous, subsessile to sessile and somewhat constricted at the base, biatorine, solitary and rounded or, eventually, shallowly lobate, occasionally clustered, then the apothecial shape often distorted by mutual pressure, (0.42–)0.72(–1) mm diam. [$n = 100$], creamy white, completely unpigmented in section; margins of immature apothecia sometimes very slightly paler, not prominent, smooth, entire, 30–60 μ m thick in surface view, soon becoming excluded, occasionally persistent, very inconspicuous and c. 30 μ m thick around the least convex, mature apothecia; disc initially slightly concave to plane and often with a faint dusting of what appears to be white pruina, usually becoming moderately to strongly convex at maturity, smooth, slightly to distinctly glossy, epruinose. *Thalline excipulum* absent. *Proper excipulum* well-developed, colourless throughout, cupulate, paraplectenchymatous, K–, I–, N–, 30–50(–70) μ m thick laterally (thin section), 60–100 μ m thick at the base, internally opaque and heavily impregnated with calcium oxalate (H_2SO_4^+), the outer

20–30 μm and a well-defined, 15–25 μm thick layer subtending the hypothecium lacking calcium oxalate; outermost cells rounded, tightly packed, rather thick-walled, 5–7(–8) μm wide, the subhypothecial cells similar but somewhat periclinally elongate. *Epihymenium* 8–12(–15) μm thick, with dense, minute, colourless crystals that dissolve in K. *Hypothecium* colourless, 30–50 μm thick, paraplectenchymatous, K–, I+ blue, N–. *Hymenium* 50–65 μm thick, not interspersed with granules or oil globules, I+ blue, K–; *paraphyses* tightly conglutinate in water, a little looser in K, mostly unbranched, although sparingly branched below the apices, lacking anastomoses, long-celled, 1.5–2 μm thick; apices not or scarcely swollen (clavate and up to 2.5 μm wide), not pigmented. *Asci* narrowly to broadly clavate or cylindroclavate, 42–55 \times 12–18 μm , 8-spored, *Byssoloma*-type (Hafellner 1984). *Ascospores* colourless, irregularly biseriolate in the ascus, 1-septate at maturity, narrowly ellipsoid to oblong-ellipsoid or narrowly ovoid, usually straight, occasionally a little bent, or the septum submedian, or the proximal cell narrower and more pointed than the distal, usually slightly constricted at the septum, (11–)14.5(–18) \times (4–)5(–6) μm [$n = 100$], thin-walled, lacking a perispore; apices rounded to subacute; contents clear, each cell with 2–4 vacuoles, these sometimes giving the false impression of additional septa. *Pycnidia* very numerous, semi-immersed to 2/3 immersed in the thallus, 100–150 μm wide; apex outwardly black; apical wall dull greenish black in section, 20–25 μm thick; lateral and basal walls dark green, c. 10 μm thick; conidiogenous layer simple, the hyphae 15–25 μm long, 1.5–2 μm thick; conidia budding apically, broadly pyriform, simple, 2.5–3.5 \times 2–2.5 μm . **Figs 3, 4.**

Chemistry: Thallus K+ yellow, C–, KC–, PD–, UV–; containing atranorin (major) and thuringione (minor) by TLC.

Relationships: *Fellhanera* Vězda (Pilocarpaceae), a genus of c. 75 species, is most diverse and predominantly foliicolous in tropical and subtropical regions (Vězda 1986, Sérusiaux 1996, Lücking 2008), but it also occurs at temperate latitudes where it is more likely to grow on bark or rock (van den Boom 2004, Aptroot et al. 2009, Harris and Lendemer 2009, Kondratyuk et al. 2013). The thallus is crustose, with a chlorococcoid photobiont, and the variously coloured, mostly sessile, biatorine apothecia have a paraplectenchymatous excipulum, simple to branched paraphyses, mainly *Byssoloma*-type asci and hyaline and transversely septate to muriform ascospores, while immersed to sessile pycnidia produce minute, pyriform to bacilliform conidia.

Persistently 1-septate ascospores are found in 11 species of *Fellhanera*, including *F. incolorata*. The new lichen is broadly characterised by the whitish, minutely verruculose thallus containing atranorin and thuringione, exceptionally broad apothecia (to 1 mm wide) that lack any trace of pigment but are heavily impregnated with calcium oxalate, as well as broadly pyriform conidia. Seven others are obligately foliicolous, either lack or have different thallus chemistry and produce much smaller, pigmented apothecia: *F. congesta* (Vězda) Vězda and *F. encephalarti* (Vězda) Vězda from Tanzania, the Neotropical *F. misionensis* Ferraro & Lücking and *F. substanhopeae* Lücking, the mainly Neotropical and tropical African *F. parvula* (Vězda) Vězda, the pantropical *F. semecarpi* (Vain.) Vězda, and *F. vandenberghenii* (Sérus.) Vězda from tropical South America and Zimbabwe (Vězda 1986, Sérusiaux 1996, Lücking 2008). Two recently described Korean species, *F. chejuensis* L.Lökös, S.Y.Kondr. & J.-S.Hur and *F. maritima* L.Lökös, S.Y.Kondr. & J.-S.Hur, grow on bark and maritime siliceous rock, respectively. The former has a greenish thallus, pale apothecia that are 0.15–0.3(–0.4) mm diam. and ascospores (6–)8–10(–11) \times 2.5–3.2(–3.5) μm , while *F. maritima* has a whitish, minutely areolate thallus and pale apothecia 0.15–0.3(–0.5) mm diam., with ascospores (8–)9–11(–13) \times (3–)3.5–4(–4.8) μm and conidia 3–4 \times 1–1.5(–1.8) μm (Kondratyuk et al. 2013). Finally, the subcosmopolitan *F. bouteillei* (Desm.) Vězda, which can grow on bark, siliceous rocks and leaves, differs from *F. incolorata* in having a bluish grey or bluish green and granulose thallus containing usnic and isousnic acids, pale yellowish to orange-brown or pale brown apothecia 0.1–0.4 mm diam. and narrowly pyriform conidia 3–5 \times 1.5–2 μm (van den Boom 2004, Lücking 2008, Aptroot et al. 2009).

Thirteen species of *Fellhanera* are known from Australia (McCarthy 2017), all but two being obligately foliicolous. The exceptions are *F. bouteillei* (see above) and *F. tropica* Elix, from the Northern Territory, which has brown to dark brown apothecia at maturity and 3–5-septate ascospores of 15–20 \times 4–6 μm (Elix 2008).

Etymology: The specific epithet refers the apothecia that lack all traces of pigmentation.

Distribution and habitat: *Fellhanera incolorata* is known only from narrow branches (to 3 cm wide) and twigs of an *Avicennia marina* tree in a mangrove swamp along a tidal creek on the south coast of New South Wales, Australia. A sparse, associated, epiphytic lichen flora also includes *Amandinea stajscii* Elix & Kantvilas (reported here for the first time from New South Wales) and *Scoliciosporum umbrinum* (Ach.) Arnold.

Additional specimen examined: NEW SOUTH WALES: South Coast : type locality, sea level, on *Avicennia marina*, J.A.Elix 46317, 19 Nov 2016 (CANB).

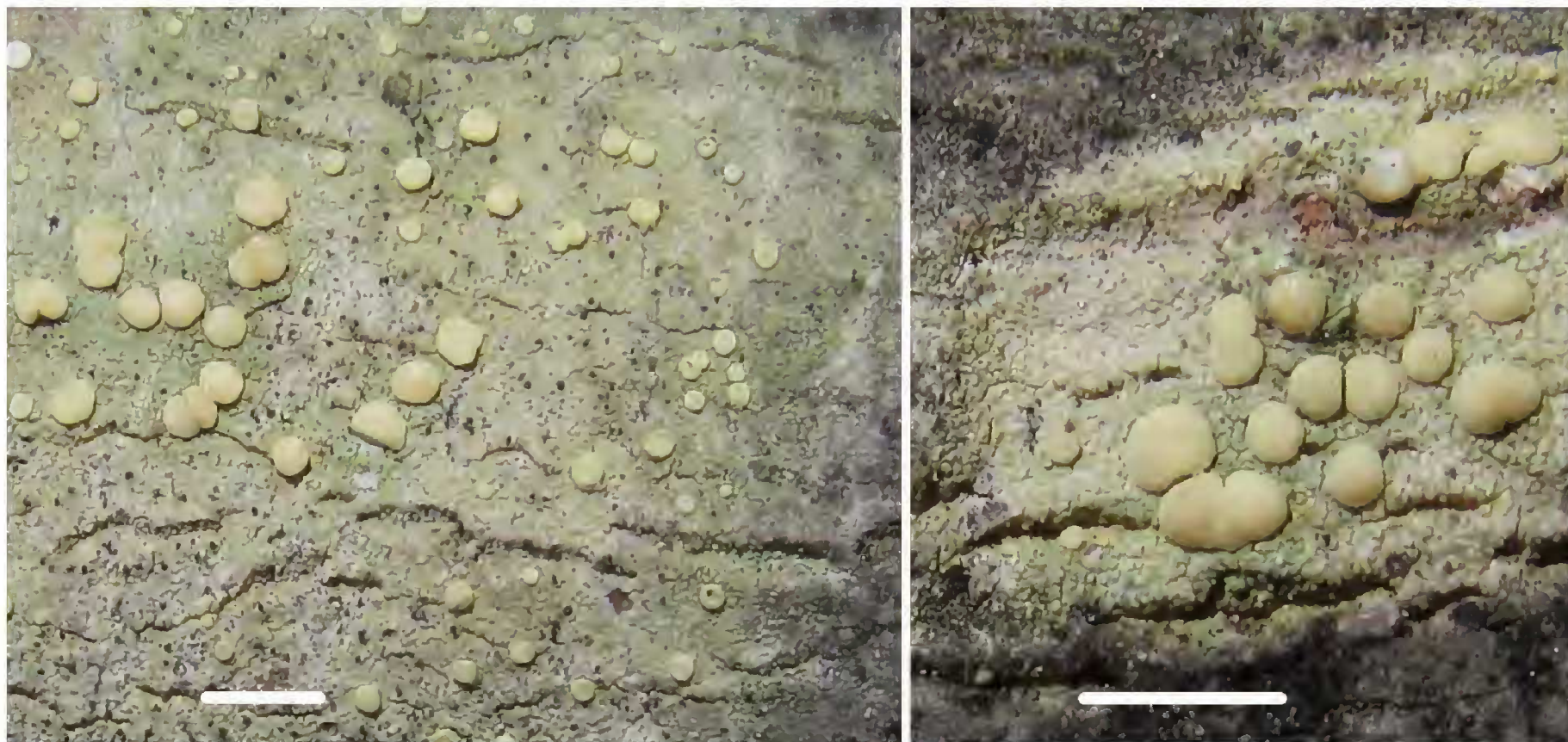


Fig 3. *Fellhanera incolorata* (holotype). Two thalli. Scale bars = 2 mm.

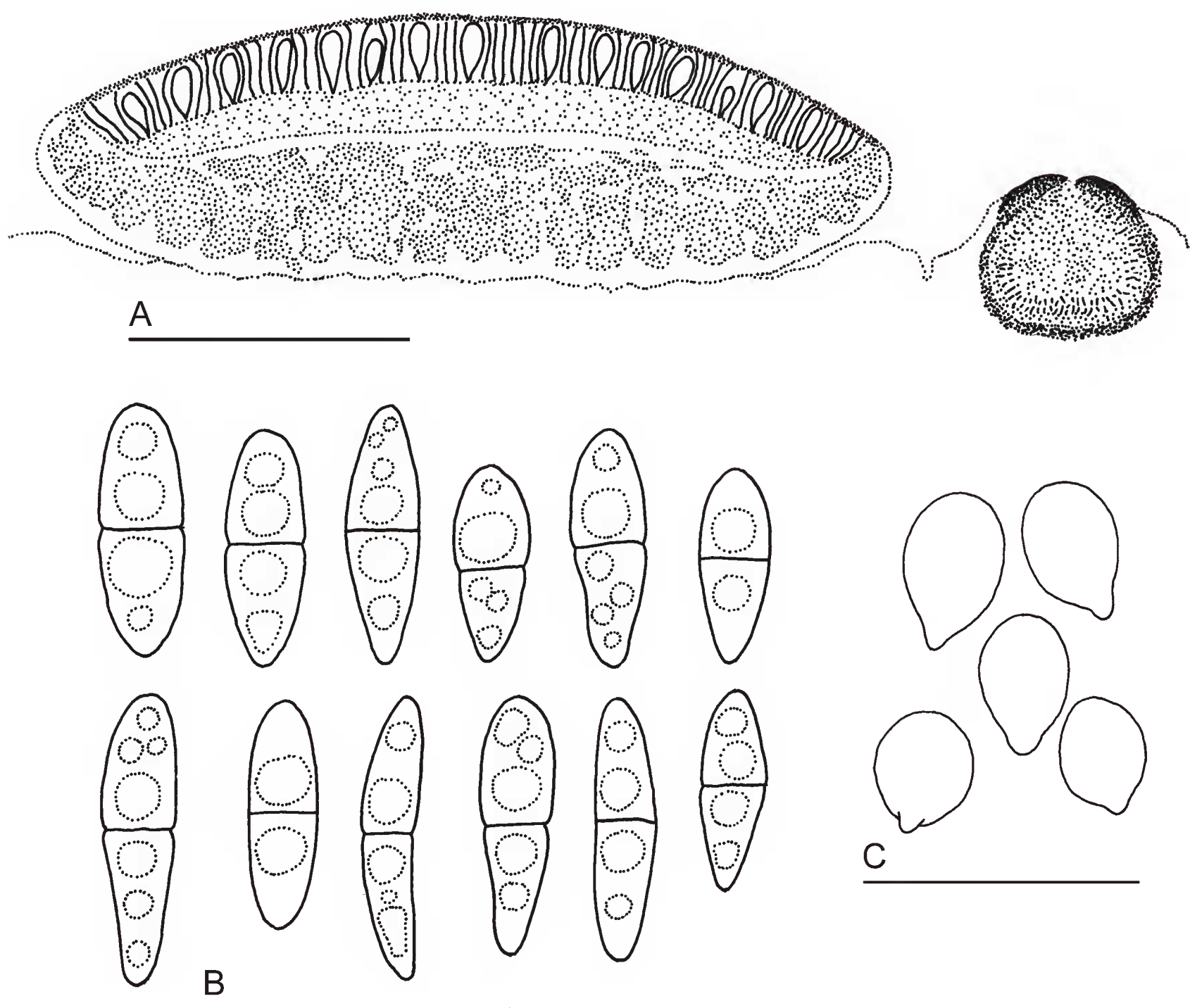


Fig 4. *Fellhanera incolorata* (holotype). A, sectioned apothecium and pycnidium (semi-schematic); B, ascospores; C, conidia. Scale bars: A = 0.2 mm; B = 20 μ m; C = 5 μ m.

3. *Opegrapha gilmorei* P.M.McCarthy & Elix, **sp. nov.**

Distinguished from *O. lithyriga* Ach. by the areolate thallus containing norstictic acid (rather than continuous and lacking lichen substances), shorter and narrower ascospores and narrowly bacilliform or fusiform conidia (filiform or broadly bacilliform in *O. lithyriga*).

MycoBank No.: MB 820668

Type: Australia. Tasmania, Bass Strait, Hunter Island Group, Albatross Island, just S of North Cave, 40° 22'S, 144°39'E, on a large conglomerate boulder in grassland, S.R. *Gilmore L10*, 10 Sep 2002 (holo: CANB).

Thallus epilithic, crustose, determinate, off-white to pale greenish grey or with a creamy hue, to 2.5 cm wide, initially richly rimose, becoming areolate, the areoles angular, plane, smooth, dull, epruinose, commonly rimulose, 0.1–0.25(–0.5) mm wide, 70–120(–150) µm thick, ecorticate. *Algae Trentepohlia*, solitary or in short filaments of up to 5 cells, not occupying a distinct layer within the thallus; cells broadly ellipsoid, 7–15(–18) × 6–12(–15) µm; interstitial hyphae short-celled, 2.5–4 µm thick. *Prothallus* very thin, diffuse, fimbriate, greyish black and 1–2.5 mm wide when growing unimpeded over rock, a thin black line when contiguous with thalli of the same or other crustose species. *Ascomata* numerous, lirelliform, semi-immersed to 2/3 immersed in the thallus, at first rounded to oblong, later straight, bent, curved or irregularly sinuous, simple to sparingly branched, 0.3–1.5(–2) mm long, 0.15–0.25 mm wide [$n = 50$], dull black, epruinose, scattered or contiguous, but not overlapping; disc slit-like or gaping slightly and up to half the width of the lirella, epruinose; however, post-mature ascomata can give the erroneous impression of being white-pruinose as the hymenium is replaced by algae and thalline hyphae. *Thalline excipulum* absent. *Proper excipulum* carbonized, not or partially overgrown by the thallus, 30–50 µm thick laterally, convergent and 20–30 µm thick above, not continuous beneath the hypothecium. *Hypothecium* 25–40(–50) µm thick, pale to medium greenish brown, with or without oily inclusions, K–, I–. *Hymenium* 80–100 µm thick, hyaline to pale greenish, not interspersed with granules or oil globules, weakly amyloid above, K–, I+ greyish blue, I– towards the base. *Epihymenium* visible as a 12–20 µm thick band of medium to dark green pigment, K–, I+ greyish blue. *Paraphysoids* moderately conglomerate, not separating in K, richly branched and anastomosing throughout, short-celled to moderately long-celled, 1.5–2(–2.5) µm thick; apical cells neither swollen nor pigmented. *Asci* 8-spored, *Vulgata*-type (*sensu* Torrente and Egea 1989, Ertz and Egea 2007), broadly cylindrical or cylindroclavate, laterally thin-walled, 60–78 × 13–18 µm; apex rounded, with a 2.5–4 µm thick tholus and, usually, a minute, conical to tuberculate ocular chamber 2–4 µm wide and 1.5–2.5 µm tall which is enclosed by a faint I+ blue ring, the remainder of the tholus non-amyloid; ascoplasma I+ reddish. *Ascospores* intermediate between *Varia*- and *Vulgata*-types (*sensu* Torrente and Egea 1989, Ertz and Egea 2007), colourless, irregularly biserial in the ascus, (5–)6(–7)-septate at maturity, narrowly oblong to fusiform, usually straight, occasionally slightly curved, not constricted at the septa, (17–)21(–25) × (2–)3.3(–4) µm [$n = 30$], excluding the perispore; cells of ± equal size throughout spore ontogeny or the middle 1 or 2 cells somewhat larger at maturity; perispore to 1 µm thick around immature and submature spores, non-granular; apices rounded or subacute; contents clear. *Pycnidia* numerous, semi-immersed to 2/3 immersed, solitary, 80–150 µm wide, black and convex above, the wall 20–40 µm thick, hyaline at the base, often largely disintegrating but persisting as a black ring. *Conidia* hyaline, simple, bacilliform or narrowly fusiform, straight, 3–6 × *c.* 0.5 µm. **Figs 5, 6.**

Chemistry: Thallus K– or K+ yellow solution ± forming red, needle-like crystals, C–, KC–, PD–, UV–; norstictic acid (major) by TLC. Norstictic acid is not uniformly distributed through the thallus of this species. Therefore, while the TLC results are consistent, spot tests are not.

Relationships: The genus *Opegrapha* Ach. (Opegraphaceae) includes approximately 300 species that grow mainly on bark, but also on leaves or as parasites of other lichens, while a small minority grow directly on rock. Most are found in the tropics and subtropics, but there is also significant diversity at temperate latitudes in both hemispheres. The genus is characterized by having a crustose, ecorticate thallus that contains *Trentepohlia* or *Phycopeltis* (foliicolous species only) as the photobiont and usually lacks lichen substances, lirellate and non-stromatic ascomata with a completely or partially carbonized excipulum, anastomosing paraphysoids, fissitunicate, mostly 8-spored asci and elongate ascospores that usually have 3- or more transverse septa (Hayward 1977, Clauzade and Roux 1985, Torrente and Egea 1989, Ertz and Egea 2007, Galloway 2007, Lücking 2008, Ertz 2009, Ertz et al. 2009, Pentecost and James 2009, Seavey et al. 2014). Forty-four species and infraspecific taxa have been reported from Australia (McCarthy 2017) but most, especially the non-foliicolous representatives, are very much in need of a comprehensive re-assessment.

Opegrapha gilmorei is distinguished by its pale, areolate, saxicolous thallus containing norstictic acid, narrow, elongate lirellae with a lateral excipulum only, narrowly oblong to fusiform, (5–)6(–7)-septate ascospores and comparatively small, bacilliform conidia. The saxicolous *O. lithyrgea* Ach., a widespread but usually uncommon, saxicolous lichen in Europe, North America, Africa and Asia, has an almost continuous thallus that is concolorous with or considerably darker than that of *O. gilmorei*, both having delicate lirellae with a slit-like disc and 5–7-septate ascospores (Pentecost and James 2009). However, the ascospores of *O. lithyrgea* are longer and broader, dimorphic conidia can be filiform or more broadly bacilliform ($3\text{--}5 \times 1\text{--}1.2 \mu\text{m}$), and the thallus lacks lichen substances. The New Zealand species *O. spodopolia* Nyl. also has an open ascomatal base, similarly septate but broader ascospores and a darker and thicker thallus that lacks lichen substances (Hayward 1977).

Lichen substances in general, and norstictic acid in particular, are rare in *Opegrapha*. The diagnostic compound of *O. gilmorei* being known from the corticolous, Australasian species *O. stellata* C.Knight (Hayward 1977) as well as the corticolous *O. mozambica* Vain. from southern Africa, and the Palaeotropical *O. semiatra* Müll.Arg. (Ertz 2009).

Etymology: The new species is named after the collector of the holotype, Dr Scott R. Gilmore.

Distribution and habitat: *Opegrapha gilmorei* is known only from Albatross Island in western Bass Strait, Tasmania. The lichen grows on exposed siliceous rocks in grassland, in association with *Amandinea decedens* (Nyl.) Blaha, H.Mayrhofer & Elix, *A. pelidna* (Ach.) Fryday & L.Arcadia, *Caloplaca whinrayi* S.Kondr. & Kärnefelt and several other *Caloplaca* species.



Fig 5. *Opegrapha gilmorei* (holotype). Scale bar = 2 mm.

4. *Protoparmelia ewersii* Elix & P.M.McCarthy, **sp. nov.**

Similar to *Protoparmelia pulchra* Diederich, Aptroot & Sérus., but differs in having larger ascospores and in containing a cohort of aliphatic acids.

MycoBank No.: MB 820669

Type: Australia. South Australia, Lofty North district, Dublin, reserve opposite old school beside oval, 34°27'S, 138°21'E, on wood, *W.H. Ewers* 2421, 22 Jan 1988 (holo: CANB).

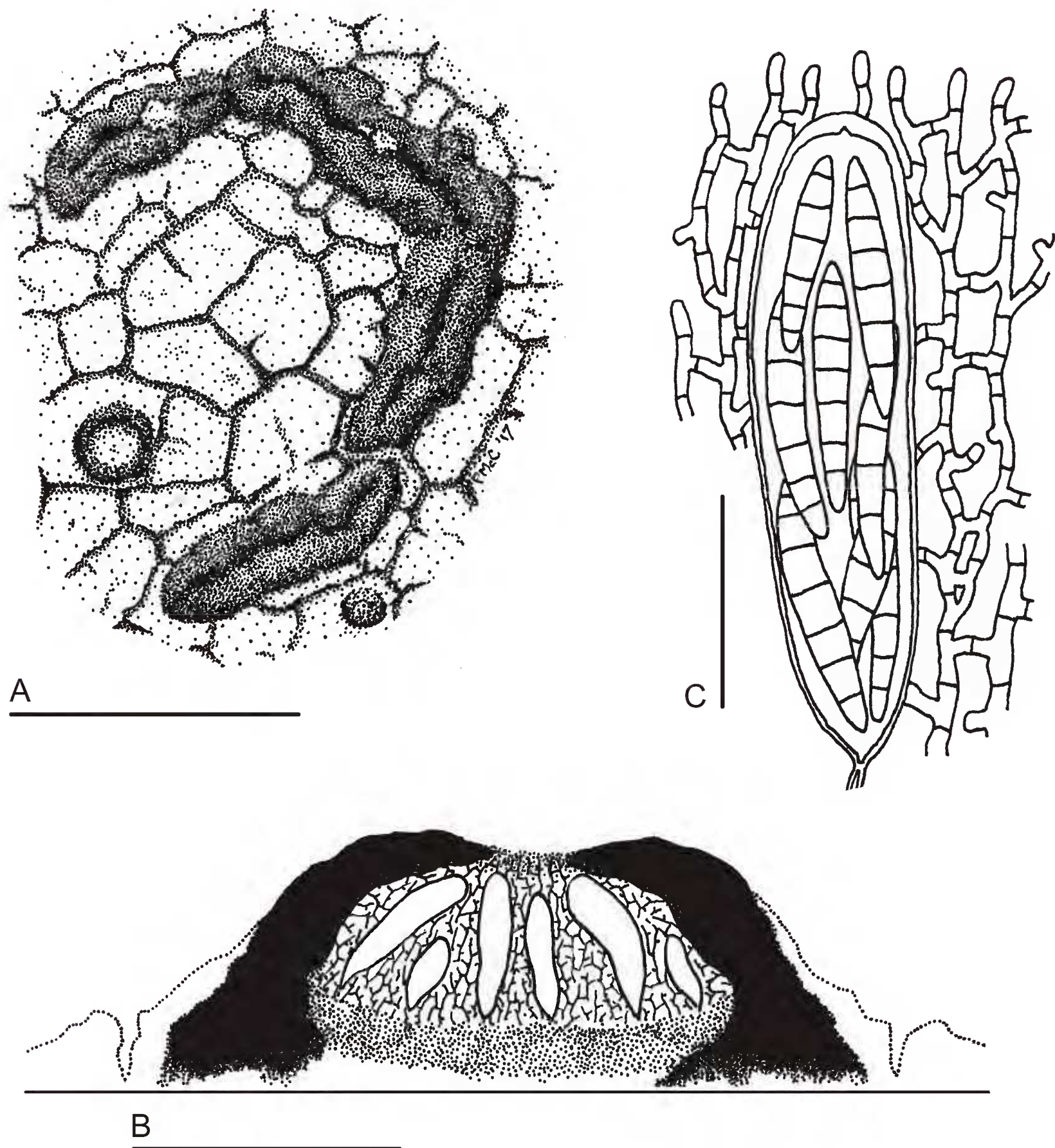


Fig 6. *Opegrapha gilmorei* (holotype). **A**, habit of thallus, lirellae and pycnidia; **B**, sectioned lirella (semi-schematic); **C**, mature ascus and paraphysoids. Scale bars: **A** = 0.5 mm; **B** = 0.1 mm; **C** = 20 μm.

Thallus crustose, to c. 20 mm wide, thin and membranous to thicker (0.5 mm thick) and verruculose-areolate; individual areoles irregular, convex, rounded, 0.1–0.5 mm wide, contiguous or scattered; upper surface whitish, pale brown to pale grey-brown; soredia and isidia absent; prothallus marginal, white or not apparent. *Photobiont* a unicellular green alga with more or less globose cells 7–15 μm wide. *Upper and lower cortex* absent. *Apothecia* 0.3–1.5 mm wide, lecanorine, scattered or clustered, round, undulate or distorted by mutual pressure, broadly adnate to sessile and basally constricted; disc mid-brown, dark brown to brown-black, matt to shiny, epruinose, weakly concave to weakly convex; thalline excipulum smooth to undulate, pale, whitish to very pale brown, prominent and usually persistent, 50–120 μm thick, sometimes curved over the disc; proper excipulum poorly delimited, pale to dark brown, 15–25 μm thick. *Epihymenium* 12–20 μm thick, orange-brown, K–, N–. *Hypothecium* 75–100 μm thick, colourless to pale yellowish brown. *Hymenium* 75–100 μm thick, IKI+ pale blue, not inspersioned, agglutinated in water and K, upper part concolorous with the epihymenium, K–, lower part pale yellow to colourless; paraphyses short and robust, branched near the tips, rarely anastomosing, septate, 3–5 μm wide; apical cells neither swollen nor pigmented. *Asci* clavate, 35–55 × 15–20 μm, 8-spored, of the *Protoparmelia*-type (Hafellner 1984; Aptroot et al. 1997a): tholus amyloid, penetrated entirely by a narrow, cylindrical, non-amyloid *masse axiale*; ocular chamber lacking. *Ascospores* simple, colourless, thick-walled, broadly ellipsoid, non-halonate, 12–[14.1]–17 × 7–[7.6]–10 μm, neither curved nor constricted. *Pycnidia*

uncommon, immersed in the thallus and evident as minute, black spots; conidia filiform, curved, $18\text{--}25 \times 0.7\text{--}1 \mu\text{m}$. **Fig. 7.**

Chemistry: Thallus K–; medulla K–, C–, P–, UV–; containing constipatic acid (minor), protoconstipatic acid (major), isomyelochroic acid (minor), myelochroic acid (major).

Relationships: A revision of the Australian species of *Protoparmelia* appeared in the *Flora of Australia* (Elix 2009b). At that time, *Protoparmelia* included only four Australian taxa. Subsequently, a further species was described (Elix and Kantvilas 2009) and, following the synonymization of *Maronina* Hafellner & R.W.Rogers with *Protoparmelia* (Papong et al. 2011), three more species were added to the Australian checklist. The present new species is characterized by the thin and membranous to thicker and verruculose-areolate, whitish to grey-brown thallus, the sessile, undulate or distorted lecanorine apothecia, the simple, ellipsoid, thick-walled ascospores, $12\text{--}17 \times 7\text{--}10 \mu\text{m}$, and the presence of a cohort of fatty acids of the constipatic acid chemosyndrome. Morphologically, *P. ewersii* closely resembles *P. pulchra*, but that species differs in containing alectoronic and dehydroalectoronic acids and in having much narrower ascospores, $2\text{--}3 \mu\text{m}$ wide. Chemically, *P. ewersii* is identical to *P. nebulosa* Elix & Kantvilas, known from New South Wales and Western Australia, but the latter has an isidiate upper surface and smaller ascospores, $10\text{--}13 \times 2.0\text{--}3.5 \mu\text{m}$. Interestingly, a chemical race of the fertile, saxicolous species, *P. montagnei* (Fr.) Poelt & Nimis, also contains a chemosyndrome of fatty acids (Barbero et al. 2006) related but not identical to that observed in *P. nebulosa* (Aptroot et al. 1997b, Barbero et al. 2006, Elix 2009b, Elix and Kantvilas 2009).

Etymology: The species is named after the collector of the type specimen, the late Dr W. H. (Bill) Ewers.

Distribution and habitat: At present this new species is known from dead wood in South Australia and two localities in the Northern Territory. Common associated species in the Northern Territory included *Buellia rechingeri* Zahlbr., *Chrysothrix xanthina* (Vain.) Kalb, *Coccocarpia palmicola* (Spreng.) Arv. & D. J. Galloway, *Cratiria lauricassiae* (Fée) Marbach, *Dirinaria consimilis* (Stirt.) D. D. Awasthi, *D. picta* (Sw.) Schaer. ex Clem., *Pertusaria velata* (Turner) Nyl., *Protoparmelia pulchra* and *P. isidiata* Diederich, Aptroot & Sérus.

Additional specimens examined: NORTHERN TERRITORY: Litchfield National Park, Tabletop Range, 25 km SW of Batchelor, $13^{\circ}11'S$, $130^{\circ}50'E$, alt. 180 m, on dead wood in burnt *Eucalyptus* woodland with dense understorey of *Grevillea*, *Owenia* and *Acacia* amongst sandstone boulders, J.A. Elix 27519A, H.T. Lumbsch & H. Streimann, 2 Jul 1991 (CANB); Litchfield National Park, Tabletop Range, 39 km SW of Batchelor, $13^{\circ}12'S$, $130^{\circ}41'E$, alt. 120 m, on dead *Eucalyptus* branch on rocky sandstone plateau with *Eucalyptus*, *Terminalia*, *Calytrix* and *Ficus*, J.A. Elix 27631, H.T. Lumbsch & H. Streimann, 4 Jul 1991 (CANB).



Fig 7. *Protoparmelia ewersii* (holotype). Scale bar = 1 mm.

5. *Ramboldia buleensis* Elix & P.M.McCarthy, sp. nov.

Similar to *Ramboldia arandensis* (Elix) Kalb, Lumbsch & Elix, but differs in having a papillate surface and in containing additional squamatic acid.

MycoBank No.: MB 820670

Type: Australia. New South Wales, Southern Tablelands, Bulee Gap, 8 km NE of Nerriga, just S of Morton National Park, 35°05'18"S, 150°08'22"E, alt. 690 m, on *Melaleuca* in open *Eucalyptus* woodland with *Acacia* and *Kunzea* understorey, J.A. Elix 39722, 31 Oct 2007 (holo: CANB).

Thallus crustose, to c. 35 mm wide and 2 mm thick, rimose to verrucose-areolate; individual areoles irregular, convex, rounded, to 2.5 mm wide; upper surface medium to dark brown, papillate, the papillae 0.05–0.1 mm wide, rarely sparsely isidiate; soredia absent; prothallus absent. *Photobiont* a unicellular green alga with more or less globose cells 8–18 µm wide. *Apothecia* 0.5–1.6 mm wide, biatorine, roundish or rather irregularly distorted, scattered or clustered, broadly adnate; disc dark brown to brown-black, matt to shiny, epruinose, plane at first, then weakly convex; proper excipulum concolorous with the disc, entire, persistent, in section 50–80 µm thick, brown, K–, open beneath the hypothecium (annular). *Epihymenium* 8–10 µm thick, orange-brown to deep orange, K+ magenta, N–. *Hypothecium* 60–75(–100) µm thick, colourless to pale brown; subhypothecium medium brown to dark brown, 90–110 µm thick. *Hymenium* 60–75 µm thick, agglutinated in water and K, upper part concolorous with the epihymenium, K+ red-violet, lower part yellow-orange; asci narrowly clavate, 24–34 × 11–14 µm, approximating the *Lecanora*-type; paraphyses 1.5–2.5 µm thick, rather robust, simple to sparsely branched and anastomosed, apices neither pigmented nor swollen. *Ascospores* hyaline, simple, oblong to ellipsoid, 8–[10.4]–13 × 2–[2.5]–3.5 µm, often 2–4-guttulate. *Pycnidia* uncommon, immersed in the thallus and evident as minute, black spots; conidia filiform, curved, 14–18 × 0.7–1 µm. **Figs 8, 9.**

Chemistry: Cortex K–; medulla K–, C–, P–, UV+ vivid white; containing atranorin (trace), chloroatranorin (trace), squamatic acid (major), fumarprotocetraric acid (minor), russulone (trace), norrussulone (trace).



Fig 8. *Ramboldia buleensis* (holotype). Scale bar = 1 mm.

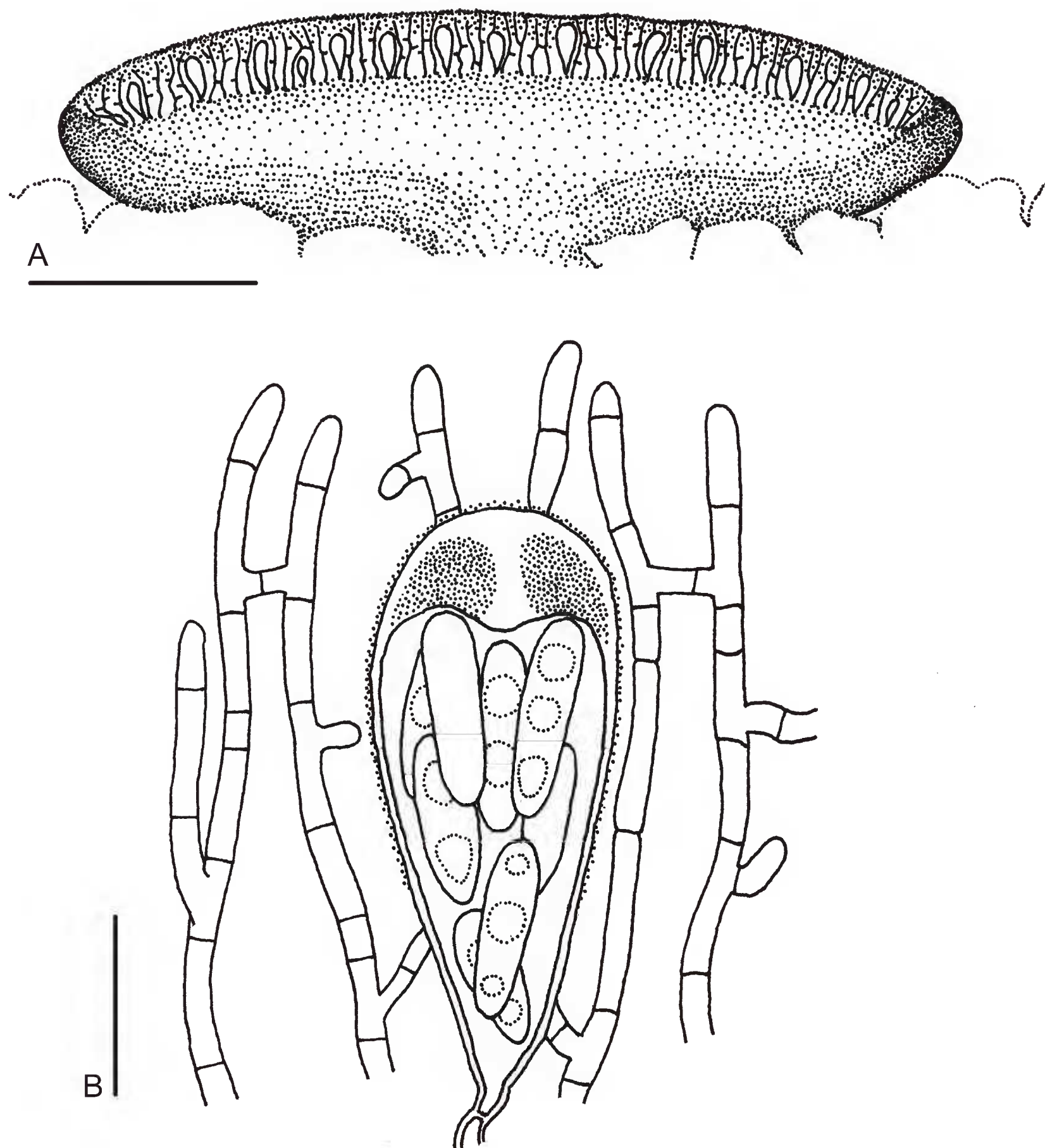


Fig 9. *Ramboldia buleensis* (holotype). **A**, sectioned apothecium (semi-schematic); **B**, mature ascus stained with Lugol's iodine after pre-treatment with K, and paraphyses. Scale bars: **A** = 0.2 mm; **B** = 10 µm.

Relationships: The most recent revision of the Australian species of *Ramboldia* appeared in the *Flora of Australia* (Elix 2009a). At that time sixteen species of *Ramboldia* were recognized for Australia. Subsequently Kantvilas (2016) described two further species and, with the addition of *R. buleensis* and *R. subplicatula* (below), nineteen species are now known from Australia. An updated key to *Ramboldia* in Australia is provided below. *Ramboldia buleensis* is characterized by the thick, crustose, medium to dark brown, rimose to verrucose-areolate, papillate to sparsely isidiate thallus, the large, broadly adnate, biatorine apothecia, the simple, oblong to ellipsoid, commonly guttulate ascospores, 8–13 × 2–3.5 µm, and the presence of squamatic and fumarprotocetraric acids and traces of russulone. It closely resembles *R. arandensis*, but that species has a granular-isidiate upper surface and it lacks squamatic acid. In addition, the thallus is corticolous and the disc dark brown to brown-black in *R. buleensis*, whereas the thallus of *R. arandensis* is lignicolous and the disc pinkish brown to deep reddish brown (Elix 2009a, Kalb et al. 2008).

Etymology: The species is named after the type locality.

Distribution and habitat: At present, this new species is only known from the type locality. Associated species included *Buellia xanthonica* (Elix) Elix, *Graphis mucronata* Stirt., *Hypogymnia billardi* (Mont.) Filson, *Megalania melaloma* (C.Knight) Kantvilas and *Pertusaria erythrella* Müll.Arg.

6. *Ramboldia subplicatula* Elix & P.M.McCarthy, sp. nov.

Similar to *R. plicatula* (Müll.Arg.) Kantvilas & Elix, but differs in having a K+ red-violet epihymenium and subhypotheceum and in lacking baecomycesic acid.

MycoBank No.: MB 820671

Type: Australia. New South Wales, Shingle Ridge, 5 km N of Molong along road to Yeoval, 33°04'22"S, 148°49'45"E, 595 m alt., on sandstone rocks in remnant *Eucalyptus* woodland along ridge, J.A. Elix 38567, 13 Oct 2005 (holo: CANB; iso: NSW).

Thallus crustose, to c. 50 mm wide and 2 mm thick, bullate and verrucose-areolate to sublobate; individual areoles irregular, convex, rounded, 0.5–2 mm wide, becoming aggregated and imbricate to form a secondarily bullate, warted or subsquamulose crust; upper surface medium to dark brown, corticate; soredia and isidia absent; prothallus absent. *Photobiont* a unicellular green alga with more or less globose cells 7–15 µm wide. *Apothecia* 0.2–0.8 mm wide, biatorine, roundish or rather irregularly distorted, scattered or clustered, broadly adnate to sessile and basally constricted, often aborted and lacking hymenial tissue; disc dark brown to brown-black, matt to shiny, epruinose, plane at first, soon convex; proper excipulum concolorous with the disc, entire, crenulate or flexuose, becoming excluded or inapparent in older apothecia, in section 40–60 µm thick, mid-brown to dark brown in outer part, K+ red-violet in part, yellow-brown within, open beneath the hypotheceum (annular). *Epihymenium* 10–13 µm thick, dark brown, K+ pale red-violet in part, N-. *Hypotheceum* 40–75 µm thick, colourless to pale yellowish brown; subhypotheceum medium brown to dark brown, 100–125 µm thick, K+ pale red-violet. *Hymenium* 40–70 µm thick, agglutinated in water and K, upper part concolorous with the epihymenium, K+ red-violet, lower part pale yellow to colourless; asci narrowly clavate, 35–50 × 11–15 µm, approximating the *Lecanora*-type; paraphyses 1.5–2.5 µm thick, rather robust, simple to sparsely branched and anastomosed, apices not pigmented, slightly swollen, 2.5–3.5 µm thick. *Ascospores* hyaline, simple, oblong to ellipsoid, 7–[9.7]–12 × 3–[4.0]–5 µm, often curved, sometimes weakly constricted. *Pycnidia* uncommon, immersed in the thallus and evident as minute, black spots; conidia filiform, curved, 18–25 × 0.7–1 µm. **Fig. 10.**



Fig 10. *Ramboldia subplicatula* (holotype). Scale bar = 1 mm.

Chemistry: Cortex K-; medulla K-, C-, P-, UV+ vivid white; containing squamatic acid (major), russulone (trace).

Relationships: This new species is characterized by the thick, crustose, medium to dark brown, bullate to verrucose-areolate or sublobate thallus, the small, adnate to sessile, biatorine apothecia, simple, oblong to ellipsoid, commonly curved ascospores, $7\text{--}13 \times 2.5\text{--}5 \mu\text{m}$, and the presence of squamatic acid and traces of russulone. The latter anthraquinone pigment is responsible for the characteristic K⁺ red-violet reactions of the epihymenium and subhypotheceum of this species. It closely resembles *R. plicatula*, but that species differs in containing both baeomycesic and squamatic acids and in having a K⁻ epihymenium and subhypotheceum (Elix 2009a).

Etymology: The species is named for its similarity to *Ramboldia plicatula*.

Distribution and habitat: At present, this new species is known from two localities in central-western New South Wales where it occurs in siliceous rocks in open *Eucalyptus* woodland. Common associated species included *Carbonea latypizodes* (Müll.Arg.) Knoph & Rambold, *Diploschistes euganeus* (A.Massal.) J.Steiner, *Lepraria dibenzofuranica* Elix, *Pertusaria xanthoplaca* Müll.Arg., *Ramboldia blastidiata* Kantvilas & Elix, *Xanthoparmelia filarszkyana* (Gyeln.) Hale, *X. rimalis* (Kurok.) Elix, A.Thell & Søchting and *X. verisidiosa* (Essl.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch.

Additional specimens examined: NEW SOUTH WALES: Goonoo State Forest, Cashels Dam Road, 31 km SE of Gilgandra, 31°55'57"S, 148°52'17"E, alt. 390 m, on sheltered sandstone ledge in open *Eucalyptus* woodland with sandstone outcrops, J.A. Elix 37986, 37988, 12 Oct 2005 (CANB).

Key to *Ramboldia* in Australia

- 1 Apothecia orange, red or red-brown or dark brown; epihymenium K⁺ purple at least in part; russulone present..... 2
- 1: Apothecia black or brown; epihymenium K⁻ or K⁺ pale grey-brown or olive-brown; russulone absent..... 12
- 2 Thallus on bark or wood 3
- 2: Thallus on rock..... 10
- 3 Thallus papillate, isidiate or granular-isidiate; fumarprotocetraric acid present 4
- 3: Thallus not papillate or isidiate; fumarprotocetraric acid present or absent..... 5
- 4 Thallus papillate to sparsely isidiate; apothecia dark brown to brown-black; squamatic acid present *R. buleensis*
- 4: Thallus isidiate or granular-isidiate; apothecia pinkish brown to red-brown; squamatic acid absent..... *R. arandensis*
- 5 Thallus orange-red or red..... *R. aurea*
- 5: Thallus grey-white to grey-green or olive-brown 6
- 6 Disc red-brown, with a distinct black margin *R. atromarginata*
- 6: Disc uniformly red, red-brown or black 7
- 7 Thallus olive-brown, bullate-areolate, smooth and glossy *R. bullata*
- 7: Thallus grey-white to grey-green, continuous to granular or areolate, rough and dull 8
- 8 Thallus thin, inconspicuous or absent, UV⁻; lichexanthone absent *R. laeta*
- 8: Thallus thick, prominent, areolate-cracked, UV⁺ yellow; lichexanthone present 9
- 9 Medulla K⁺ red, P⁺ orange; norstictic acid present *R. haematites*
- 9: Medulla K⁺ pale yellow-brown, P⁺ red-orange; fumarprotocetraric acid present *R. quaesitica*
- 10 Thallus white or off-white, UV⁺ yellow; lichexanthone present.....*R. sanguinolenta*
- 10: Thallus olive-grey to brown, UV⁻; lichexanthone absent 11
- 11 Disc bright scarlet red to brownish red; medulla UV⁻; squamatic acid absent *R. greeniana*
- 11: Disc dark brown to brown-black; medulla UV⁺ vivid white; squamatic acid present *R. subplicatula*
- 12 Thallus on bark or wood 13
- 12: Thallus on rock..... 19

- 13 Thallus sorediate or blastidiate 14
- 13: Thallus lacking soredia and blastidia 16
- 14 Thallus brownish or pale grey-green, blastidiate, K+ red; norstictic acid present **R. blastidiata**
- 14: Thallus pale grey or yellow-grey, sorediate, K+ yellow or purple; norstictic acid absent 15
- 15 Thallus UV+ white, K+ purple; hypothamnolic acid present **R. farinosa**
- 15: Thallus UV-, K+ intense yellow; thamnolic acid present **R. sorediata**
- 16 Disc orange-brown to dark reddish brown; thallus K+ red; norstictic acid present **R. brunneocarpa**
- 16: Disc black; thallus K+ yellow or purple; norstictic acid absent 17
- 17 Thallus containing hypothamnolic acid; subhypothecium K+ purple **R. stuartii**
- 17: Thallus containing thamnolic acid; subhypothecium and thallus K+ yellow 18
- 18 Thallus bullate-areolate; areolae 0.2–0.5 mm wide, 0.2–0.5 mm thick; paraphyses slender and evenly tapered, lacking oil inclusions **R. crassithallina**
- 18: Thallus of scattered or ±contiguous convex areolae c. 0.25 mm wide, to 0.1 mm thick; paraphyses conspicuously vacuolate and swollen with oil inclusions **R. subnexa**
- 19 Thallus and apothecia K+ red; norstictic acid present **R. petraeoides**
- 19: Thallus and apothecia K-; norstictic acid absent 20
- 20 Cortex K+ yellow; baeomycesic and squamatic acids present **R. plicatula**
- 20: Cortex K-; squamatic acid present; baeomycesic acid absent **R. subplicatula**

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